09/914818

U.S. Application No.

International Application No.
PCT/JP00/007499

Attorney Docket No.
KITANO.010AUS

Date: August 31, 2001

JC05 Rec'd PCT/PTO 31 AUG 2001

TRANSMITTAL LETTER TO THE UNITED STATES DESIGNATED/ELECTED OFFICE (DO/EO/US) CONCERNING A FILING UNDER 35 USC 371

International Application No.:	PCT/JP00/07499
International Filing Date:	October 26, 2000
Priority Date Claimed:	January 6, 2000
Title of Invention:	CHEMICAL SUBSTANCE DETECTING METHOD AND APPARATUS
Applicant(s) for DO/EO/US:	Kazuyuki Maruo

Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information:

1. (X) This is a first submission of items concerning a filing under 35 USC 371.

2. (X) This express request to begin national examination procedures (35 USC 371(f)) at any time rather than delay examination until the expiration of the applicable time limit set in 35 USC 371(b) and PCT Articles 22 and 39(1).

3. () A proper Demand for International Preliminary Examination was made by the 19th month from the earliest claimed priority date.

4. (X) A copy of the International Application as filed (35 USC 371(c)(2))
   a. (X) is transmitted herewith (required only if not transmitted by the International Bureau).
   b. () has been transmitted by the International Bureau.
   c. () is not required, as the application was filed in the United States Receiving Office (RO/US).

5. (X) A translation of the International Application into English (35 USC 371(c)(2)).

6. () Amendments to the claims of the International Application under PCT Article 19 (35 USC 371(c)(3))
   a. () are transmitted herewith (required only if not transmitted by the International Bureau).
   b. () have been transmitted by the International Bureau.
   c. () have not been made; however, the time limit for making such amendments has NOT expired.
   d. () have not been made and will not be made.

7. () A translation of the amendments to the claims under PCT Article 19 (35 USC 371(c)(3)).

8. (X) A **unsigned** declaration of the inventor(s) (35 USC 371(c)(4)) and Power of Attorney.

9. () A copy of the International Preliminary Examination Report.

10. () A translation of the annexes, such as any amendments made under PCT Article 34, to the International Preliminary Examination Report under PCT Article 36 (35 USC 371(c)(5)).

11. (X) An Information Disclosure Statement under 37 CFR 1.97 and 1.98A with PTO-1449 form.

12. () An assignment document for recording. A separate cover sheet in compliance with 37 CFR 3.28 and 3.31 is included.

13. (X) A FIRST preliminary amendment.

14. () A substitute specification.

15. (X) A copy of International Search Report by EPO.

16. () A copy of International Preliminary Examination Report by EPO.

17. (X) A return prepaid postcard.

18. () Small entity status is hereby claimed.

19. (X) The following fees are submitted:

				FEES
BASIC FEE (37 CFR 1.492(a)(5))				$860
Surcharge of $130 for furnishing the oath or declaration after 20/30 months from the earliest claimed priority date (37 CFR 1.492(e))				$0
CLAIMS	**NUMBER FILED**	**NUMBER EXTRA**	**RATE**	
Total Claims	22 - 20 =	2 ×	$18	$36
Independent Claims	3 - 3 =	0 ×	$80	$0
Multiple dependent claims(s) (if applicable)			$270	$0
TOTAL OF ABOVE CALCULATIONS				$896
Reduction by 1/2 for filing by small entity (if applicable). Verified Small Entity statement must also be filed. (NOTE 37 CFR 1.9, 1.27, 1.28)				$0
TOTAL NATIONAL FEE				$896
TOTAL FEES ENCLOSED				$896

20. (X) A check in the amount of $896 to cover the above fees is enclosed.

21. () Fee for recording the enclosed assignment (37 CFR 1.21(h)). The assignment must be accompanied by an appropriate cover sheet (37 CFR 3.28, 3.31). $40 per property.

22. () A copy of forms PCT/IB/304 and PCT/IB/308.

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083001

09/914818

31 AUG 2001

KITANO.010AUS

PATENT

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicant	: Kazuyuki Maruo	)	Group Art Unit
Serial No.	: New Application	)	
Filed	: Concurrently Herewith	)	
For	: CHEMICAL SUBSTANCE DETECTING METHOD AND APPARATUS	)	
Examiner	: Unknown	)	

PRELIMINARY AMENDMENT

Hon. Commissioner
of Patents and Trademarks
Washington, D.C. 20231

Dear Sir:

This amendment is submitted for the above-identified patent application filed concurrently herewith. Please make the following changes:

IN THE CLAIMS:

Please cancel Claims 1-12 and please add Claims 13-34 as follows:

13. A chemical substance detecting apparatus comprising:

a chemical substance decomposing means for decomposing a substance-to-be-detected adhering to an impurity and eliminating from the impurity a chemical substance characterizing the substance-to-be-detected;

a chemical substance detecting means for detecting the chemical substance; and

a filter for selectively admitting the chemical substance to the chemical substance detecting means,

the substance-to-be-detected being indirectly detected based on a detected result of the chemical substance.

14. A chemical substance detecting apparatus comprising:

a chemical substance decomposing means for decomposing a substance-to-be-detected adhering to an impurity and eliminating from the impurity a chemical substance characterizing the substance-to-be-detected; and

a chemical substance detecting means for detecting the chemical substance,

the substance-to-be-detected being indirectly detected based on a detected result of the chemical substance.

15. A chemical substance detecting apparatus according to claim 13, wherein

the chemical substance decomposing means is an UV radiation generator for applying an UV radiation to the substance-to-be-detected.

16. A chemical substance detecting apparatus according to claim 14, wherein

the chemical substance decomposing means is an UV radiation generator for applying an UV radiation to the substance-to-be-detected.

17. A chemical substance detecting apparatus according to claim 13, wherein

the chemical substance decomposing means is a plasma generator for exposing the substance-to-be-detected to a plasma.

18. A chemical substance detecting apparatus according to claim 14, wherein

the chemical substance decomposing means is a plasma generator for exposing the substance-to-be-detected to a plasma.

19. A chemical substance detecting apparatus according to claim 17, wherein

the plasma generator produces the plasma by a high-voltage pulse.

20. A chemical substance detecting apparatus according to claim 18, wherein

the plasma generator produces the plasma by a high-voltage pulse.

21. A chemical substance detecting apparatus according to claim 17, wherein

the plasma generator produces the plasma by a microwave.

22. A chemical substance detecting apparatus according to claim 18, wherein

the plasma generator produces the plasma by a microwave.

23. A chemical substance detecting apparatus according to claim 13, wherein

the chemical substance detecting means comprises: an infrared radiation source for applying an infrared radiation to an atmosphere containing the chemical substance; and an infrared radiation detector for detecting the infrared radiation emitted from the atmosphere, the chemical substance being detected based on an absorbed quantity of the detected infrared radiation.

24. A chemical substance detecting apparatus according to claim 14, wherein

the chemical substance detecting means comprises: an infrared radiation source for applying an infrared radiation to an atmosphere containing the chemical substance; and an infrared radiation detector for detecting the infrared radiation emitted from the atmosphere, the chemical substance being detected based on an absorbed quantity of the detected infrared radiation.

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25. A chemical substance detecting apparatus according to claim 13, wherein

the chemical substance detecting means comprises: an infrared transmitting substrate for adhering the chemical substance; an infrared radiation source for applying an infrared radiation to the infrared transmitting substrate; and an infrared radiation detector for detecting the infrared radiation which has undergone multiple reflection inside the infrared transmitting substrate and exited the infrared transmitting substrate, the chemical substance being detected based on an absorbed quantity of the detected infrared radiation.

26. A chemical substance detecting apparatus according to claim 14, wherein

the chemical substance detecting means comprises: an infrared transmitting substrate for adhering the chemical substance; an infrared radiation source for applying an infrared radiation to the infrared transmitting substrate; and an infrared radiation detector for detecting the infrared radiation which has undergone multiple reflection inside the infrared transmitting substrate and exited the infrared transmitting substrate, the chemical substance being detected based on an absorbed quantity of the detected infrared radiation.

27. A chemical substance detecting apparatus according to claim 25, further comprising

an UV radiation applying means for applying an UV radiation to the infrared transmitting substrate to clean surfaces of the infrared transmitting substrate.

28. A chemical substance detecting apparatus according to claim 26, further comprising

an UV radiation applying means for applying an UV radiation to the infrared transmitting substrate to clean surfaces of the infrared transmitting substrate.

29. A chemical substance detecting apparatus according to claim 23, wherein

the chemical substance detecting means further comprises a spectroscope which spectrally analyzes the infrared radiation detected by the infrared radiation detector, and identifies a kind of the chemical substance and/or quantifies the chemical substance.

30. A chemical substance detecting apparatus according to claim 24, wherein

the chemical substance detecting means further comprises a spectroscope which spectrally analyzes the infrared radiation detected by the infrared radiation detector, and identifies a kind of the chemical substance and/or quantifies the chemical substance.

31. A chemical substance detecting apparatus according to claim 25, wherein

the chemical substance detecting means further comprises a spectroscope which spectrally analyzes the infrared radiation detected by the infrared radiation detector, and identifies a kind of the chemical substance and/or quantifies the chemical substance.

32. A chemical substance detecting apparatus according to claim 26, wherein

the chemical substance detecting means further comprises a spectroscope which spectrally analyzes the infrared radiation detected by the infrared radiation detector, and identifies a kind of the chemical substance and/or quantifies the chemical substance.

33. A chemical substance detecting method comprising:

decomposing a substance-to-be-detected adhering to an impurity;

eliminating from the impurity a chemical substance characterizing the substance-to-be-detected;

detecting the eliminated chemical substance; and

indirectly detecting the substance-to-be-detected, based on a detected result of the chemical substance.

34. A chemical substance detecting method according to claim 33, wherein

the eliminated chemical substance is detected after separated from the impurity.

REMARKS

This amendment is submitted to correct the multiple dependent forms in the original claims.

Applicant respectfully requests that the preliminary amendment noted above be entered before the substantive examination of this case.

Respectfully submitted,

MURAMATSU & ASSOCIATES

Dated: 8/31/01

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JC03 Rec'd PCT/PTO 31 AUG 2001

DESCRIPTION

CHEMICAL SUBSTANCE DETECTING METHOD AND APPARATUS

[TECHNICAL FIELD]

The present invention relates to a chemical substance detecting method and apparatus for identifying a chemical substance, such as an environmental pollutant in the atmosphere, or measuring a concentration of the chemical substance.

[BACKGROUND ART]

Recently, environmental pollution caused by a trace of chemical substance in the atmosphere, such as problems of environmental pollution with dioxin, etc., is a matter of concern. The so-called environmental monitoring systems for detecting a trace of chemical substance in the atmosphere, identifying the chemical substance and measuring concentration thereof are increasingly needed.

As a conventional method for detecting chemical substances present in the atmosphere is used, for example, GC-MS (Gas Chromatography-Mass Spectroscopy) in which a gas to be measured is adsorbed on a porous substance, such as TENAX or others, the porous substance is heated to release the adsorbed chemical substances, and components of the chemical substances are identified and quantified by mass

spectrometer.

As another method for detecting chemical substances in the atmosphere is used the so-called FT-IR (Fourier Transform-Infrared Spectroscopy) in which infrared radiation is applied to a gas to be measured, and absorption spectra are analyzed. Infrared absorption spectra are intrinsic of substances. Infrared radiation spectra are analyzed to identify chemical substances in a gas to be measured, and concentrations of the chemical substances can be quantified.

However, the conventional GC-MS takes tens hours for the measurement, and the measurement is not real time. The column for the GS-MS must be prepared in a laboratory, which makes it impossible to measure an environment in-situ. It is difficult to feedback a measurement result to the control of environments.

Certain chemical substances, such as dioxin, etc., are generated, adsorbed on impurity particles, as of smoke exhausted from waste burning plants. In using the GC-MS for detecting such chemical substances, the smoke is collected, is repeatedly subjected to chemical treatments, such as sulfuric acid treatment, etc., and is subjected to the mass spectrometry. Such complicated processing is required.

In the FT-IR, smoke particles absorb or irregularly reflect the infrared radiation. It is often that a

spectrum of an intended chemical substance cannot be obtained correctly or with high sensitivity.

[DISCLOSURE OF INVENTION]

An object of the present invention is to provide a chemical substance detecting method and apparatus for measuring with high sensitivity and real time various chemical substances including chemical substances, such as dioxin, etc., generated, adsorbed on impurity particles.

The above-described object is achieved by a chemical substance detecting apparatus comprising: a chemical substance decomposing means for decomposing a substance-to-be-detected adhering to an impurity and eliminating from the impurity a chemical substance characterizing the substance-to-be-detected; a chemical substance detecting means for detecting the chemical substance; and a filter for selectively admitting the chemical substance to the chemical substance detecting means, the substance-to-be-detected being indirectly detected based on a detected result of the chemical substance.

The above-described object is also achieved by a chemical substance detecting apparatus comprising: a chemical substance decomposing means for decomposing a substance-to-be-detected adhering to an impurity and eliminating from the impurity a chemical substance characterizing the substance-to-be-detected; and a chemical

substance detecting means for detecting the chemical substance, the substance-to-be-detected being indirectly detected based on a detected result of the chemical substance.

In the above-described chemical substance detecting apparatus, it is possible that the chemical substance decomposing means is an UV radiation generator for applying an UV radiation to the substance-to-be-detected.

In the above-described chemical substance detecting apparatus, it is possible that the chemical substance decomposing means is a plasma generator for exposing the substance-to-be-detected to a plasma.

In the above-described chemical substance detecting apparatus, it is possible that the plasma generator produces the plasma by a high-voltage pulse.

In the above-described chemical substance detecting apparatus, it is possible that the plasma generator produces the plasma by a microwave.

In the above-described chemical substance detecting apparatus, it is possible that the chemical substance detecting means comprises: an infrared radiation source for applying an infrared radiation to an atmosphere containing the chemical substance; and an infrared radiation detector for detecting the infrared radiation emitted from the atmosphere, the chemical substance being detected based on an absorbed quantity of the detected infrared radiation.

In the above-described chemical substance detecting apparatus, it is possible that the chemical substance detecting means comprises: an infrared transmitting substrate for adhering the chemical substance; an infrared radiation source for applying an infrared radiation to the infrared transmitting substrate; and an infrared radiation detector for detecting the infrared radiation which has undergone multiple reflection inside the infrared transmitting substrate and exited the infrared transmitting substrate, the chemical substance being detected based on an absorbed quantity of the detected infrared radiation.

In the above-described chemical substance detecting apparatus, it is possible that the apparatus further comprises an UV radiation applying means for applying an UV radiation to the infrared transmitting substrate to clean surfaces of the infrared transmitting substrate.

In the above-described chemical substance detecting apparatus, it is possible that the chemical substance detecting means further comprises a spectroscope which spectrally analyzes the infrared radiation detected by the infrared radiation detector, and identifies a kind of the chemical substance and/or quantifies the chemical substance.

The above-described object is also achieved by a chemical substance detecting method comprising: decomposing a substance-to-be-detected adhering to an impurity;

eliminating from the impurity a chemical substance characterizing the substance-to-be-detected; detecting the eliminated chemical substance; and indirectly detecting the substance-to-be-detected, based on a detected result of the chemical substance.

In the above-described chemical substance detecting method, it is possible that the eliminated chemical substance is detected after separated from the impurity.

According to the present embodiment, a substance-to-be-measured (e.g., dioxin) adsorbed on smoke particles is decomposed, a chemical substance characterizing the substance-to-be-measured generated by the decomposition is selectively introduced into the detection system to be detected, whereby the substance-to-be-measured can be indirectly detected, and the substance-to-be-measured can be detected with high sensitivity without the influence of the smoke particles.

The measurement by the detection system using FT-IR is real time, and the detecting time can be much shorter in comparison with that of the detecting method using the conventional GC-MS. The multiple internal reflection FT-IR is used in the detection system, whereby detection sensitivity of detecting a substance-to-be-measured can be much higher.

[BRIEF DESCRIPTION OF DRAWINGS]

FIG. 1 is a diagrammatic view showing the principle of the chemical substance detecting method and apparatus according to the present invention.

FIG. 2 is a view of one example of plasma generating apparatuses applicable to the present invention.

FIG. 3 is a view of one example of Fourier Transform Infrared Spectroscopes applicable to the present invention.

FIG. 4 is a graph of the infrared absorption of chlorophenol.

FIG. 5 is a diagrammatic view of the chemical substance detecting method and apparatus according to a first embodiment of the present invention.

FIG. 6 is a diagrammatic view of the chemical substance detecting method and apparatus according to a second embodiment of the present invention.

FIG. 7 is a diagrammatic view of the chemical substance detecting method and apparatus according to a third embodiment of the present invention.

FIG. 8 is a diagrammatic view of the chemical substance detecting method and apparatus according to a fourth embodiment of the present invention.

FIG. 9 is a diagrammatic view of the chemical substance detecting method and apparatus according to a fifth embodiment of the present invention.

FIG. 10 is a diagrammatic view of the chemical substance detecting method and apparatus according to a

sixth embodiment of the present invention.

[BEST MODES FOR CARRYING OUT THE INVENTION]

[Principle of the Present Invention]

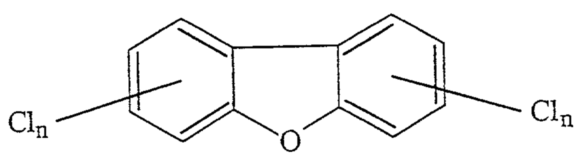
The principle of the chemical substance detecting method and apparatus according to the present invention will be explained with reference to FIGs. 1 to 4.

FIG. 1 is a diagrammatic view showing the principle of the chemical substance detecting method and apparatus according to the present invention. FIG. 2 is a view of one example of a plasma generating apparatus. FIG. 3 is a view of one example of Fourier Transform Infrared Spectroscope. FIG. 4 is a graph of the infrared absorption spectrum of chlorophenol.

As shown in FIG. 1, the chemical substance detecting apparatus according to the present invention is characterized mainly by comprising chemical substance decomposing means 10 which decomposes a substance-to-be-detected adsorbed on an impurity to release a specific chemical substance from the substance-to-be-detected, a filter 50 which select the thus released specific chemical substance, and chemical substance detecting means 30 which computes a quantity of the substance-to-be-detected adsorbed on the impurity, based on a quantity of the detected specific chemical substance.

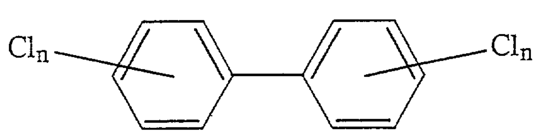
The respective constituent members of the chemical

substance detecting method and apparatus according to the present invention will be respectively described below in good detail. In the following description, the present invention will be explained by means of a case of detecting dioxin generated at waste burning plants or the like. However, chemical substances which can be detected by the chemical substance detecting method and apparatus according to the present invention are not limited to dioxin. The chemical substance detecting method and apparatus according to the present invention can detect other environmental pollutants, e.g., polychlorodibenzofuran (PCDF) expressed by the Formula (1),



...(1)

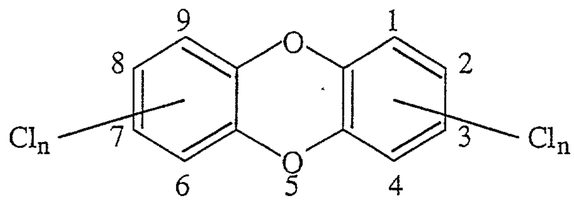
and PCB (polychlorinated biphenyl) group expressed by the Formula (2).



...(2)

(a) Chemical Substance Decomposing Means 10

Dioxin is formally called polychlorodibenzo-p-dioxin and has the structure expressed by the Formula (3).

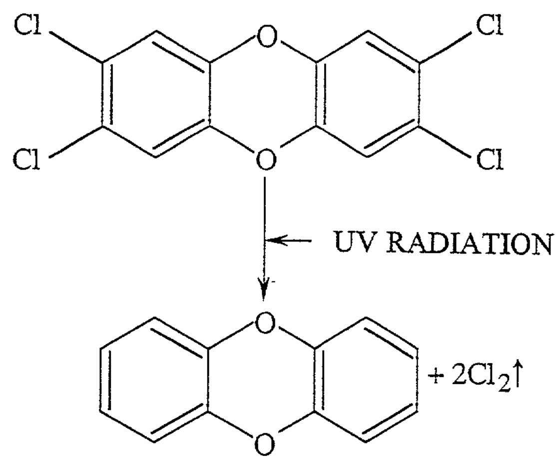


...(3)

Eight chlorine atoms at most can substitute hydrogens at the positions 1 to 4 and the positions 6 to 9 of Formula (3). Dioxin has 75 isomers which depend on total numbers and positions of chlorine. These isomers are collectively called dioxin group or simply dioxin.

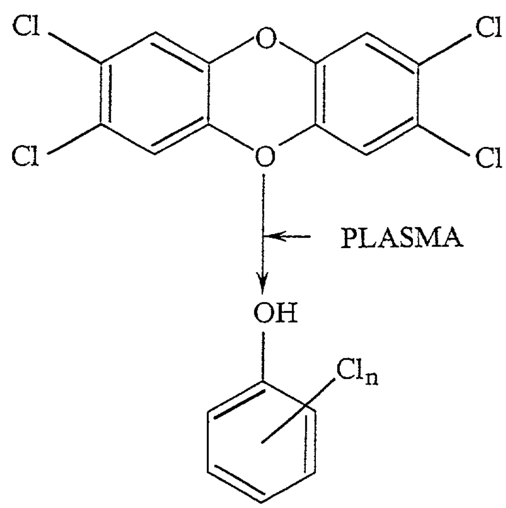
Dioxin group is generated mainly as burnt ashes of waste burning plants, and most of the dioxin group is exhausted, adsorbed on smoke particles generated at the waste burning plants. Smoke particles have a molecular weight of about 10^6 - 10^8, and dioxin group has a molecular weight of about 300. To accurately quantify the dioxin group, it is preferable to desorbed the dioxin group from the smoke particles.

Dioxin, which is a solid crystal, is difficult to be desorbed from smoke particles, retaining the structure to be measured. However, it is known that when high energy is applied to dioxin, dioxin undergoes the decomposition reaction expressed by Reaction Formula (4)



...(4)

or the decomposition reaction expressed by Reaction Formula (5).



...(5)

The reaction expressed by Reaction Formula (4) takes place under application of UV radiation, and the UV radiation application eliminates chlorine from dioxin. The eliminated chlorine is detected, whereby dioxin can indirectly detected.

The chemical substance decomposing means for causing

the reaction expressed by Reaction Formula (4) is provided by an UV radiation application source which applies UV radiation to smoke particles. The UV radiation application source has higher energy than the bonding energy of the chlorine of dioxin. The UV radiation source can be provided by, e.g., a low pressure mercury lamp which emits Xe (xenon) excimer beams of a 185 nm and a 254 nm emission wavelengths, a dielectric barrier discharge excimer lamp having an emission wavelength of a 172 nm emission wavelength, or others. UV radiation having such energy is applied to dissociate the C-Cl bonds to thereby eliminate chlorine gas from dioxin adsorbed on smoke particles.

The reaction expressed by Reaction Formula (5) is caused by applying plasma energy to dioxin. Smoke particles are exposed to plasmas to decompose dioxin to generate a substance chlorophenol. Chlorophenol is liquid at room temperature and has the boiling point of 175 °C, and, in plasma environments, is vaporized and desorbed from smoke particles. The desorbed chlorophenol is detected to indirectly detect dioxin.

The chemical substance decomposing means 10 for applying plasma energy to dioxin to cause the reaction expressed by Reaction Formula (5) is provided by the plasma generating means exemplified in FIG. 2. A plasma means a gas in which freely mobile electrons and ions are sufficiently present, and a total sum of charges is

macroscopically zero. A plasma is generated by electrons bound by atoms being ionized by energy, and basically has a high temperature (electron temperature, ion temperature and gas temperature). Plasmas are used as various energy sources for nuclear fusion, lasers, chemical activation, etc.

In the present invention, nitrogen and oxygen in air is made into the plasma state to use the energy to decompose and eliminate a chemical substance in an impurity. As exemplified in FIG. 2, plate electrodes 20, 22 are opposed to each other, and a high-voltage AC electric field is applied by a high-voltage AC source 24 connected between the electrodes 20, 22 to produce a plasma 26 between the electrodes 20, 22. Energy of a plasma to be produced is determined by parameters, such as a source voltage, an inter-electrode distance, etc.

There are many methods and apparatuses for generating plasmas, but to relatively easily generate plasmas in a gas of about the atmospheric pressure (1 atmospheric pressure), methods using the above-described high-voltage AC source and microwaves are preferable. Either method can be used in the present invention.

(b) Chemical Substance Detecting Means 30

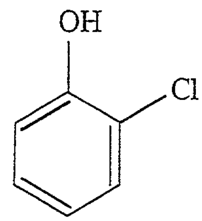
The chemical substance detecting means 30 detects specific chemical substances, e.g., chlorine and chlorophenol, eliminated from dioxin and, based on their

concentrations, computes a concentration of dioxin.

As means for detecting chemical substances, various means besides the above-described GC-MS gas chromatography can be considered, but in terms of the real-time measurement, a detection method using infrared radiation is preferable. In the present invention, Fourier transform infrared spectroscopy (FT-IR) which analyzes an infrared absorption spectrum to detect a specific substance is used.

In principle, the FT-IR comprises, as exemplified in FIG. 3, an infrared radiation source 32 which applies infrared radiation to a gas-to-be-detected, and a spectrum analyzer 34 which detects and spectroscopically analyzes the infrared radiation which has passed through the gas-to-be-detected. When infrared radiation is injected into a gas-to-be-detected with a specific chemical substance mixed in, the substance absorbs the infrared radiation, and an absorption spectrum is formed in the output radiation. The absorption spectrum is intrinsic of the chemical substance to which the infrared radiation has been applied. Accordingly, infrared radiation is applied to a gas-to-be-detected, the output radiation is spectrally diffracted, and an absorption spectrum is analyzed, whereby whether or not a specific chemical substance is present in the detected gas can be judged.

For example, chlorophenol, which is generated by decomposing dioxin, is expressed by Formula (6).



...(6)

When infrared radiation is applied to chlorophenol, the absorption spectrum shown in FIG. 4 can be obtained. Oppositely, when an absorption spectrum obtained by applying infrared radiation to a gas generated by exposing burnt ashes from a waste burning plant to plasmas are as shown in FIG. 4, it can be judged that the burnt ashes contains dioxin.

In place of a detection method in which infrared radiation is directly applied to a gas-to-be-detected, a detection method in which infrared radiation is injected into an infrared transmitting crystal substrate exposed in a gas-to-be-detected, and is multiple-reflected inside the substrate, and exit radiation from the substrate is detected and spectroscopically analyzed. Such method is detained in, e.g., the specification of Japanese Patent Application No. Hei 11-231495 (1999). The internal multiple reflection FT-IR is used, whereby specific chemical substances can be detected with higher sensitivity than in applying infrared radiation directly to the gas.

FT-IR can not only detect a quantity of a specific chemical substance as described above, but also can

identify a kind of the chemical substance and compute its quantity. The identification and quantization of a substance by using FT-IR is detained in, e.g., the specification of Japanese Patent Application No. Hei 11-95853 (1999), the specification of Japanese Patent Application No. Hei 11-231495 (1999), etc. FT-IR is detained in, e.g., Mitsuo Takuma (ed.), "Basics and practice of FT-IR, 2nd edition", Tokyo Kagaku Dojin.

(c) Filter 50

As described above, smoke particles have a molecular weight of about 10^6 - 10^8, and the dioxin group has a molecular weight of about 300. When infrared radiation is applied directly to smoke particles, there is a risk that most of the infrared radiation may be absorbed by the smoke particles, and an absorption spectrum of dioxin will not be able to be observed. In order to measure dioxin with high sensitivity, it is preferable that a specific chemical substance (e.g., chlorophenol) eliminated from dioxin which has been separated from smoke particles is measured.

As means for separating a specific chemical substance eliminated from dioxin, from smoke particles, it is effective to dispose the filter 50 between the chemical substance decomposing means 10 and the chemical substance detecting means 30.

A decomposition chamber 12 where the chemical substance decomposing means 10 is disposed is partitioned

by the filter 50 from a detection chamber 14 where the chemical substance detecting means 30 is disposed. A positive pressure is established in the decomposition chamber 12 with respect to the detection chamber 14, or a negative pressure is established in the detection chamber 14 with respect to the decomposition chamber 12 so that the gas in the decomposition chamber 12 flows to the detection chamber 14 through the filter 50. Accordingly, the filter 50 is provided by a material which does not pass particles of very large molecular weights, such as smoke particles but passes particles of small molecular weights, such as chlorophenol. Smoke particles generally have a diameter of 1 μm or more. For example, the filter of a 1 μm-mesh used in oil-repellent dust-proof masks is used. Such filter can selectively pass a specific chemical substance alone eliminated from dioxin into the detection chamber 14. To establish a positive pressure in the decomposition chamber 12 with respect to the detection chamber 14, for example, object-to-be-detected introducing means 16 for introducing burnt gas into the detection chamber 12 may be provided. To establish a negative pressure in the detection chamber 14 with respect to the decomposition chamber 12, for example, exhaust means 18 which exhausts the gas in the detection chamber 14 may be provided.

It is preferable to dispose the filter 50 for higher sensitivity of detecting dioxin, but the filter 50 is not

essential. The filter 50 is not necessary in a case that a sufficient infrared absorption spectrum of a specific chemical substance eliminated from dioxin can be obtained owing to little infrared absorption of smoke particles or other causes.

[A First Embodiment]

The chemical substance detecting method and apparatus according to a first embodiment of the present invention will be explained with reference to FIG. 5. FIG. 5 is a diagrammatic view of the chemical substance detecting method and apparatus according to the present embodiment.

First, the chemical substance detecting apparatus according to the first embodiment of the present invention will be explained with reference to FIG. 5.

The chemical substance detecting apparatus according to the present embodiment comprises a decomposition chamber 12 which decomposes a substance-to-be-measured (e.g., dioxin) contained in an impurity, such as burnt waste ashes or burn gas, to eliminate a specific chemical substance (e.g., chlorine), and a detection chamber 14 which detects the specific chemical substance obtained by decomposing the substance-to-be-measured contained in the burnt gas, and a filter 50 which divides the decomposition chamber 12 and the detection chamber 14 from each other and which block substances of large molecular weights, such as smoke particles.

The decomposition chamber 12 includes substance-to-be-detected introducing means 16 which introduces an impurity, such as burnt waste ashes, burnt gas or others, which is to be inspected. In the decomposition chamber 12, an UV radiation source 28 is disposed for decomposing a substance-to-be-measured to eliminate a specific chemical substance.

In the detection chamber 14, a Fourier transform infrared spectroscope which includes an infrared radiation source 32 and a spectrum analyzer 34, for detecting the specific substance obtained by decomposing the substance-to-be-measured contained in the burnt gas. The detection chamber 14 includes exhaust means 18 which exhausts the gas in the detection chamber 14.

As described above, in the chemical substance detecting apparatus of the present embodiment, the UV radiation source 28 is used as the chemical substance decomposing means which decompose a substance-to-be detected, such as dioxin, to eliminate a specific substance, and the Fourier transform infrared spectroscope is used as the chemical substance detecting means for detecting the specific chemical substance eliminated from the substance-to-be-detected.

The chemical substance detecting apparatus has the above-described structure, whereby dioxin adsorbed on smoke particles is exposed to UV radiation emitted from the UV

radiation source 28 to undergo the decomposition reaction expressed by Reaction Formula (4) to eliminate chlorine. A quantity of the thus generated chlorine is detected by the Fourier transform infrared spectroscope, whereby a quantity of dioxin, which is the source of generating the chlorine, can be measured.

The Fourier transform infrared spectroscope is used as the chemical substance detecting means, whereby even when a substance-to-be-measured is unknown, the substance can be identified, and a quantity of the substance can be computed.

Next, the chemical substance detecting method according to the present embodiment will be explained.

First, an impurity, such as burnt waste, burnt gas or others, which is to be detected is introduced into the decomposition chamber 12 by the substance-to-be-detected introducing means 16.

Then, UV radiation is emitted from the UV radiation source 28 to be applied to the burnt waste ashes or burnt gas introduced in the decomposition chamber 12. Dioxin adsorbed on the burnt waste ashes or burnt gas undergoes the decomposition reaction (Reaction Formula (4)) to be decomposed, and chlorine is eliminated.

At this time, a positive pressure is established in the decomposition chamber 12 with respect to the detection chamber 14, or a negative pressure is established in the

detection chamber 14 with respect to the decomposition chamber 12, whereby the gas in the decomposition chamber 12 flows to the detection chamber 14 through the filter 50. However, the filter 50 does not pass particles of large molecular weights, such as smoke particles, but passes particles alone of small molecular weights, such as chlorine. The chlorine eliminated from dioxin can be introduced selectively with respect to the smoke particles into the detection chamber 14.

Next, the substance-to-be-detected in the detection chamber 14 is analyzed by the Fourier transform infrared spectroscope. Infrared radiation emitted from the infrared radiation source 32 of the spectroscope is absorbed at a specific wavelength range by the chlorine eliminated from dioxin. Accordingly, an infrared absorption spectrum of the infrared radiation which has passed through the detection chamber 14 is analyzed, whereby a quantity of the chlorine can be detected, and resultantly the absence or presence of dioxin, which is the generation source of the chlorine, or a quantity of dioxin can be computed.

At this time, the smoke particles of large molecular weights are absent in the detection chamber 14, and accordingly no deterioration of detection sensitivity due to the smoke particles takes place.

As described above, according to the present embodiment, dioxin adsorbed on smoke particles is

decomposed, a chemical substance characterizing dioxin generated by the decomposition is introduced into the detection system to be detected, whereby dioxin can be indirectly detected, and dioxin can be detected with high sensitivity without the influence of the smoke particles.

The measurement by the detection system using FT-IR is real time, and the detecting time can be much shorter in comparison with that of the detecting method using the conventional GC-MS. Specifically in a typical example, the conventional detecting method must take a measuring time of about 1 month, but according to the present invention, dioxin can be detected in a measuring time of about 10 minutes.

In the present embodiment, the chemical substance decomposing means is provided by the UV radiation source 28 but may be provided by plasma producing mens as exemplified in FIG. 2.

In the present embodiment, the infrared radiation source 32 and the spectroscope 34 are disposed inside the detection chamber 14. However, it is possible that the infrared radiation source 32 and/or the spectroscope 34 is disposed outside the detection chamber 14, and infrared radiation emitted by the infrared radiation source 32 is introduced into the detection chamber 14 through an infrared transmitting window, or infrared radiation is emitted from the inside of the detection chamber 14 through

the infrared transmitting window to be introduced into the spectroscope 34.

In the present embodiment, the infrared radiation is analyzed by using the spectroscope, but the spectroscope is not essential. In a case of a chemical substance-to-be-detected whose infrared absorption band is known, for example, the infrared radiation in the absorption band is selectively detected, whereby a quantity of the chemical substance can be quantified, based on an intensity of the detected infrared radiation.

[A Second Embodiment]

The chemical substance detecting method and apparatus according to a second embodiment of the present invention will be explained with reference to FIG. 6. The same reference numbers of the present embodiment as those of the chemical substance detecting method and apparatus according to the first embodiment shown in FIG. 5 are represented by the same reference numbers not to repeat or to simplify their explanation. FIG. 6 is a diagrammatic view of the chemical substance detecting method and apparatus according to the present embodiment.

The chemical substance detecting apparatus according to the present embodiment is characterized in that the filter 50 is not provided between the decomposition chamber 12 and the detection chamber 14 of the chemical substance detecting apparatus according to the first embodiment shown

in FIG. 5.

The filter 50 is provided for prohibiting smoke particles having large molecular weights from entering the detection chamber 14 so as to prevent infrared radiation, the measurement radiation, from being absorbed by the smoke particles to resultantly lower detection sensitivity. However, the filter 50 is not essential in a case where smoke particles little absorb infrared radiation, and infrared absorption spectrum of chlorine eliminated from dioxin can be sufficiently obtained. This constitution of the chemical substance detecting apparatus makes the structure simple.

As described above, according to the present embodiment, it is not necessary to divide the decomposition chamber 12 from the detection chamber 14 by the filter 50, which makes the structure of the apparatus simple.

[A Third Embodiment]

The chemical substance detecting method and apparatus according to a third embodiment of the present invention will be explained with reference to FIG. 7. FIG. 7 is a diagrammatic view of the chemical substance detecting method and apparatus according to the present embodiment.

First, the chemical substance detecting apparatus according to the present embodiment will be explained with reference to FIG. 7.

The chemical substance detecting apparatus according

to the present embodiment comprises a decomposition chamber 12 which decomposes a substance-to-be-measured (e.g., dioxin) contained in an impurity, such as burnt waste ashes or burn gas, to eliminate a specific chemical substance (e.g., chlorophenol), and a detection chamber 14 which detects the specific chemical substance obtained by decomposing the substance-to-be-measured contained in the burnt gas, and a filter 50 which divides the decomposition chamber 12 and the detection chamber 14 from each other and which block substances of large molecular weights, such as smoke particles.

The decomposition chamber 12 includes substance-to-be-detected introduction means 16 which introduces an impurity, such as burnt waste ashes or burnt gas, to be detected. In the decomposition chamber 12 there is provided plasma producing means which produces plasmas for decomposing a substance-to-be-measured contained in burnt waste ashes or burnt gas to eliminate a specific chemical substance. The plasma producing mean comprises a pair of electrodes 20, 22 arranged opposed each other. The electrodes 20, 22 are connected to a high-voltage AC source 24.

The detection chamber 14 includes an infrared radiation source 32 and a spectroscope 34. In the detection chamber 14 there is provided a Fourier transform infrared spectroscope which detects a specific chemical

substance obtained by decomposing a substance-to-be-measured contained in burnt gas. The detection chamber 14 also includes exhaust means 18 which exhausts the gas in the detection chamber 14.

As described above, in the chemical substance detecting apparatus according to the present embodiment, the plasma producing means is used as the chemical substance decomposing means for decomposing a substance-to-be-detected, such as dioxin or others, to eliminate a specific chemical substance from the substance-to-be-detected, and the Fourier transform infrared spectroscope is used as the chemical substance detecting means for detecting the specific chemical substance eliminated from the substance-to-be-detected.

In the chemical substance detecting apparatus having this constitution, dioxin adsorbed on smoke particles is exposed to plasmas produced by the plasma producing means to undergo the decomposition reaction (Reaction Formula (5)) to generated chlorophenol. A quantity of the thus generated chlorophenol is detected by the Fourier transform infrared spectroscope, whereby the absence/presence of dioxin which is the generation source of the chlorophenol, and a quantity of dioxin can be computed.

The Fourier transform infrared spectroscope is used as the chemical substance detecting means, whereby even when a substance-to-be-detected is unknown, the substance can be

identified, and a quantity of the substance can be computed.

Then, the chemical substance detecting method according to the present embodiment will be explained.

First, an impurity, such as burnt water ashes, burn gas or others, which is to be detected is introduced into the decomposition chamber 12 by the substance-to-be-detected introducing means 16.

Then, plasma 26 is produced in the decomposition chamber 12 by the plasma producing means. For example, AC voltage of a 10 kV effective voltage and a 1 kHz frequency is applied between the electrodes 20, 22, whereby discharges takes place even in the atmospheric pressure, and plasmas are produced. Dioxin adsorbed on the burnt waste ashes, burn gas or others undergoes the decomposition reaction (Reaction Formula (5)) to be decomposed, and chlorophenol is generated.

At this time, a positive pressure is established in the decomposition chamber 12 with respect to the detection chamber 14, or a negative pressure is established in the detection chamber 14 with respect to the decomposition chamber 12, whereby the gas in the decomposition chamber 12 flow to the detection chamber 14 through the filter 50. However, the filter 50 does not pass particles of large molecular weights, such as smoke particles, but passes small particles of small molecular weight, such as

chlorophenol. The chlorophenol eliminated from dioxin can be introduced into the detection chamber 14 selectively with respect to the smoke particles.

Next, the impurity in the detection chamber 14 is analyzed by the Fourier transform spectroscope. Infrared radiation emitted from the infrared radiation source 32 of the spectroscope is absorbed in a specific wavelength range by the chlorophenol eliminated from dioxin. The infrared absorption spectrum is analyzed to detect a quantity of the chlorophenol which is the generation source of the chlorophenol, and a quantity of dioxin can be computed.

At this time, the smoke particle of large molecular weights is absent in the detection chamber 14, and no deterioration of detection sensitivity due to the smoke particles takes place.

As described above, according to the present embodiment, dioxin adsorbed on smoke particles is decomposed, a chemical substance characterizing dioxin, which is generated by the decomposition, is selectively introduced into the detection system to be detected, whereby dioxin can be indirectly detected, and dioxin can be detected with high sensitivity without the influence of the smoke particles.

The measurement by the detection system using FT-IR is real time, and the detecting time can be much shorter in comparison with that of the detecting method using the

conventional GC-MS. Specifically in a typical example, the conventional detecting method must take a measuring time of about 1 month, but according to the present invention, dioxin can be detected in a measuring time of about 10 minutes.

In the present embodiment, the chemical substance decomposing means is provided by the plasma producing means as shown in FIG. 2 but may be provided by the UV radiation source 28 as in the first embodiment. Other plasma producing means may be used.

[A Fourth Embodiment]

The chemical substance detecting method and apparatus according to a fourth embodiment of the present invention will be explained with reference to FIG. 8. The same members of the present embodiment as those of the chemical substance detecting method and apparatus according to the third embodiment shown in FIG. 7 are represented by the same reference numbers not to repeat or to simplify their explanation. FIG. 8 is a diagrammatic view of the chemical substance detecting method and apparatus according to the present embodiment.

As shown in FIG. 8, the chemical substance detecting apparatus according to the present embodiment is characterized in that the filter 50 is not provided between the decomposition chamber 12 and the detection chamber 14 of the chemical substance detecting apparatus according to

the third embodiment shown in FIG. 7.

The filter 50 is provided for prohibiting smoke particles having large molecular weights from entering the detection chamber 14 so as to prevent infrared radiation, the measurement radiation, from being absorbed by the smoke particles to resultantly lower detection sensitivity. However, the filter 50 is not essential in a case where smoke particles little absorb infrared radiation, and infrared absorption spectrum of chlorine eliminated from dioxin can be sufficiently obtained. This constitution of the chemical substance detecting apparatus makes the structure simple.

As described above, according to the present embodiment, it is not necessary to divide the decomposition chamber 12 from the detection chamber 14 by the filter 50, which makes the structure of the apparatus simple.

[A Fifth Embodiment]

The chemical substance detecting method and apparatus according to a fifth embodiment of the present invention will be explained with reference to FIG. 9. FIG. 9 is a diagrammatic view of the chemical substance detecting method and apparatus according to the present embodiment.

First, the chemical substance detecting apparatus according to the present embodiment will be explained with reference to FIG. 9.

[1] General Constitution of the Chemical Substance

Detecting Apparatus

The chemical substance detecting apparatus according to the present embodiment comprises a decomposition chamber 12 which decomposes a substance-to-be-measured (e.g., dioxin) contained in an impurity, such as burnt waste ashes or burn gas, to eliminate a specific chemical substance (e.g., chlorophenol), and a detection chamber 14 which detects the specific chemical substance obtained by decomposing the substance-to-be-measured contained in the burnt gas, and a filter 50 which divides the decomposition chamber 12 and the detection chamber 14 from each other and which block substances of large molecular weights, such as smoke particles.

The decomposition chamber 12 includes substance-to-be-detected introduction means 16 which introduces an impurity, such as burnt waste ashes or burnt gas, to be detected. In the decomposition chamber there is provided plasma producing means which produces plasmas for decomposing a substance-to-be-measured contained in burnt waste ashes or burnt gas to eliminate a specific chemical substance. The plasma producing mean comprises a pair of electrodes 20, 22 arranged opposed each other. The electrodes 20, 22 are connected to a high-voltage AC source 24.

The detection chamber 14 includes an infrared transmitting substrate 40 which adsorbs for the measurement

a chemical substance introduced into the detection chamber 14, an UV radiation source 42 which removes the substance adhering to the surfaces of the infrared transmitting substrate 40 to initialize a surface state of the substrate 40, an infrared radiation source 32 which applies infrared radiation into the infrared transmitting substrate 40 to cause internal multiple reflection, and a spectroscope 34 which spectrally analyzes the transmitted infrared radiation which has undergone multiple reflection inside the infrared transmitting substrate 40 and exited. The detection chamber 14 includes exhaust means 18 which exhausts gas inside the detection chamber 14.

As described above, in the chemical substance detecting apparatus according to the present embodiment, the plasma producing means is used as the chemical substance decomposing means for decomposing a substance-to-be-detected, such as dioxin or others, to eliminate a specific chemical substance from the substance-to-be-detected, and the internal multiple reflection FT-IR is used as the chemical substance detecting means for detecting the specific chemical substance eliminated from the substance-to-be-detected.

The chemical substance detecting means having this constitution can much improve detection sensitivity of detecting a chemical substance introduced into the detection chamber 14.

The respective constituent members of the chemical substance detecting means provided by the internal multiple reflection FT-IR will be explained. The respective constituent members of the chemical substance detecting means are detailed in, e.g., the specification of Japanese Patent Application No. Hei 11-95853 (1999) and the specification of Japanese Patent Application No. Hei 11-231495 (1999). The various constituent members described in these specifications are applicable to the chemical substance detecting apparatus according to the present invention.

(a) Infrared transmitting substrate 40

The infrared transmitting substrate 40, as described above, adsorbs for the measurement a chemical substance to be detected and must be made of a material which transmits light of a wavelength range corresponding to molecule vibrations of the chemical substance to be detected. A wave-number range corresponding to a basic vibrations of organic substances, which are typical pollutants, is a 500 cm^{-1} (20 μm wavelength) - 5000 cm^{-1} (2 μm wavelength) range of the infrared and near infrared radiation range. Accordingly, a material of the infrared transmitting substrate 40 is selected out of the infrared transmitting material group, which can transmit light of this wave-number range (wavelength band). For example, zinc selenide (ZnSe) has a very wide transmitted wavelength band of about

0.6 - 13 µm, and can be suitably selected as one material forming the infrared transmitting substrate 40.

It is preferable that a configuration of the infrared transmitting substrate 40 has the end surface beveled at 45° as exemplified in FIG. 9. This improves efficiency of the incidence of the infrared radiation in the infrared transmitting substrate 40 and permits the infrared radiation to undergo internal multiple reflection in the infrared transmitting substrate 40. As described in the specification of Japanese Patent Application No. Hei 11-95853 (1999), a substrate having the end configuration of a 300 mm-silicon wafer can be used.

Other materials which can form the infrared transmitting substrate 40 are, e.g., gallium arsenide (GaAs: transmitting wavelength band 1.0 - 18 µm), silicon (Si: transmitting wavelength band 2 - 6 µm), potassium bromide (KBr: transmitting wavelength band 0.4 - 22 µm), potassium chloride (KCl: transmitting wavelength band 0.3 - 15 µm, barium fluoride (BaF_2: transmitting wavelength band 0.2 - 5 µm), cesium bromide (CsBr: transmitting wavelength band 0.5 - 30 µm), germanium (Ge: transmitting wavelength band 2 - 18 µm), lithium fluoride (LiF: transmitting wavelength band 0.2 - 5 µm), calcium fluoride (CaF_2: transmitting wavelength band 0.2 - 8 µm), sapphire (Al_2O_3: transmitting wavelength band 0.3 - 5 µm), cesium iodide (CsI: transmitting wavelength band 0.5 - 28 µm), magnesium

fluoride (MgF: transmitting wavelength band 0.2 - 6 μm), thallium bromide (KRS-5: transmitting wavelength band 0.6 - 28 μm), zinc sulfide (ZnS: transmitting wavelength 0.7 - 11 μm), etc.

(b) Infrared Radiation Source 32

The infrared radiation source 32 can be provided by a light source which emits infrared radiation of a 2 - 25 μm-band corresponding to the molecular vibrations of the organic molecules. For example, heat rays which are emitted by injecting current into silicon carbide (SiC) as a filament, or a Nichrome wire may be used as the infrared radiation source. Infrared radiation sources, such as an SiC glow lamp or others, using SiC are characterized in that such sources emit infrared radiation of a 1.1 - 25 μm band, and such sources can be used naked in air without burns.

For high efficiency of the light source, and high intensity of the infrared radiation, a suitably shaped reflection plate may be provided. For example, the various infrared radiation sources described in the specification of Japanese Patent Application No. Hei 11-95843 (1999) filed by the same applicant as the present application.

(c) Spectroscope 34

When infrared radiation injected into the infrared transmitting substrate 40 undergoes internal multiple reflections, a frequency component of evanescent light

generated when the infrared radiation is reflected on the substrate surfaces, which agrees with a molecular vibration frequency of a pollutant on the substrate surfaces is resonance absorbed. Accordingly, the injected infrared radiation is caused to undergo multiple reflection inside the infrared transmitting substrate 40, whereby the infrared radiation can indicate information of the substrate surface state. Infrared absorption spectrum of the infrared radiation exiting the infrared transmitting substrate 40 is analyzed, whereby a kind and a quantity of an organic pollutant can be identified.

FIG. 4 is a graph of an absorption spectrum of infrared radiation detected after the multiple reflection inside the infrared transmitting substrate 40 with chlorophenol adhering to, which has been given by diffracting by Fourier transform. As shown, peaks are observed in the wave number range corresponding to a molecule vibration of a specific organic pollutant, whereby the organic pollutant can be identified as chlorophenol. Adhesion quantities of the organic pollutant can be computed based on intensities of the peaks. Chlorophenol could be detected in the absorption spectrum shown in FIG. 4 when chlorophenol adheres to the surfaces of the infrared transmitting substrate 40 by 5×10^{11} molecules/cm^2 or more.

In place of the FT-IR, an infrared spectrometer using a diffraction grating may be used.

(d) UV radiation source 42

The chemical substance detecting apparatus according to the present invention is for measuring a pollutant in an environmental atmosphere, such as burnt waste ashes, burnt gas, etc. by identifying and quantifying a chemical substance adsorbed on the surfaces of the infrared transmitting substrate 40. A quantity of a pollutant, which can be adsorbed on the infrared transmitting substrate 40 is saturated as time passes. In a case that changes of concentrations of a pollutant in the atmosphere must be investigated over a long period of time, a cleaning step of periodically removing the pollutant adhering to the surfaces of the infrared transmitting substrate 40 is necessary.

The chemical substance detecting apparatus according to the present embodiment include an infrared radiation source 42 as the cleaning means for removing a chemical substance adhering to the substrate. The UV radiation source 42 is for dissociating and evaporating a chemical substance adhering to the surfaces of the infrared transmitting substrate 40 and emits radiation of higher energy than a bonding energy of the chemical substance adsorbed on the substrate surfaces. The UV radiation source can be provided by, e.g., a Xe (xenon) excimer radiation, a low-pressure mercury lamp having 185 nm- and 254 nm-emission wavelengths, a dielectric barrier discharge

excimer lamp having a 172 nm-emission wavelength or others. Radiation of such energy is applied to dissociate bonds of organic pollutants, such as C-C, C-H, C-O, etc. to remove or evaporate the organic pollutants from the surfaces of infrared transmitting substrate 40.

As a member subordinate to the infrared radiation source 42, a reflection mirror (not shown) may be provided for effectively applying the UV radiation emitted form the UV radiation source 42 to the infrared transmitting substrate 40. For example, the reflection mirror of empirical section as described in the specification of Japanese Patent Application No. Hei 11-231495 (1999) is used so that the UV radiation emitted from the UV radiation source 42 can be effectively applied to both sides of the infrared transmitting substrate 40.

For the removal of a chemical substance, other chemical or physical removing methods may be used. In the chemical substance detecting apparatus according to the present embodiment, the reflection and absorption take place on each side of the upper surface and the back surface of the infrared transmitting substrate 40. Both surfaces of the infrared transmitting substrate 40 must be cleaned.

(e) Computing / Display Means (not shown)

Measured data of a spectrum given by the spectroscope are supplied to computing/display means, where a chemical

substance is identified, and a quantity of the chemical substance is computed.

Kinds and calibration curves of chemical substances are separately prepared and stored in the memory of the computing/display means. With reference to the data, measured data are quantified.

The computing/display means stores as data base relationships between quantities of chemical substances adsorbed on the surfaces of the infrared transmitting substrate 40 and quantities of pollutants in environmental atmospheres. Based on a detected quantity of a pollutant on the surfaces of the infrared transmitting substrate 40, a concentration of the pollutant in an environmental atmosphere can be computed.

A thus-analyzed result can be displayed as required on a display (not shown).

[2] Chemical Substance Detecting Method

The chemical substance detecting method according to the present embodiment will be explained.

First, an impurity, such as burnt waste ashes, burnt gas or others, to be detected is introduced into the decomposition chamber 12 by the substance-to-be-detected introducing means 16.

Then, a plasma 26 is produced in the decomposition chamber 12 by the plasma producing means. By applying an AC voltage of a 10 kV effective voltage and a 1 kHz

frequency between the electrodes 20, 22, discharge takes place under the atmospheric pressure, and the plasma 26 is produced. Dioxin adhering to the burnt waste ashes or burnt gas is decomposed by the plasma in accordance with decomposition reaction (Reaction Formula (5)), and chlorophenol is generated.

At this time, a positive pressure is established in the decomposition chamber 12 with respect to the detection chamber 14, or a negative pressure is established in the detection chamber 14 with respect to the decomposition chamber 12, whereby the gas in the decomposition chamber 12 flows to the detection chamber 14 through the filter 50. However, the filter 50 does not pass particles of large molecular weights, such as smoke particles, but passes particles alone of small molecular weights, such as chlorophenol. The chlorophenol eliminated from dioxin can be introduced selectively with respect to the smoke particles into the detection chamber 14.

The chlorophenol introduced into the detection chamber 14 is adsorbed on the surfaces of the infrared transmitting substrate 40 disposed in the detection chamber 14.

Next, the chlorophenol adhering to the infrared transmitting substrate is quantified by the chemical substance detecting means.

First, infrared radiation emitted by the infrared radiation source 32 is injected into the infrared

transmitting substrate 40. The infrared radiation injected into the infrared transmitting substrate 40 undergoes internal multiple reflection on the front and the back surfaces of the infrared transmitting substrate 40 while probing to accumulate information of chlorophenol, and exits the infrared transmitting substrate 40.

Then, the infrared radiation exiting the infrared transmitting substrate 40 is spectrally analyzed by the spectroscope 34, chlorophenol is quantified by the computing/display means (not shown), and based on a quantity of the chlorophenol, which is the generation source of dioxin, the absence/presence of dioxin or a quantity of dioxin is computed.

At this time, smoke particles of large molecular weights are not present in the detection chamber, and deterioration of detection sensitivity due to the smoke particles does not take place.

Next, UV radiation emitted by the UV radiation source 42 is applied as required to the infrared transmitting substrate 40 to remove the pollutant adsorbed on the surfaces of the infrared transmitting substrate 40, and the substrate surfaces are initialized.

Then, the above-described measurement is repeated as required to measure transient changes, etc. of a pollutant in an environmental atmosphere.

As described above, according to the present

embodiment, dioxin adsorbed on smoke particles is decomposed, and a chemical substance characterizing dioxin generated by the decomposition is selectively introduced into the detection system and detected. Based on the detected chemical substance characterizing dioxin, dioxin is indirectly detected, whereby dioxin can be detected with high sensitivity without the influence of the smoke particles.

The measurement by the detection system using FT-IR is real time, whereby a detection time can be much decreased in comparison with the detecting method using GC-MS. In typical measuring examples, the conventional detecting method takes about 1 month for the measurement, but the present invention can detect dioxin in about 10 minutes of the measurement. The detection system uses internal multiple reflection FT-IR, whereby the detection sensitivity of detecting dioxin can be much improved.

In the present embodiment, the plasma producing means shown in FIG. 2 is used as the chemical substance decomposing means, but the UV radiation source 28 may be used as in the first embodiment. Other plasma producing means may be used.

In the present embodiment, infrared radiation is analyzed by using a spectroscope, but it is not essential that the spectroscope is disposed. For example, when an infrared absorption band of a chemical substance to be

detected is known, infrared radiation in the absorption band is selectively detected, whereby a quantity of the chemical substance is quantified based on an intensity of the detected infrared radiation.

[A Sixth Embodiment]

The chemical substance detecting method and apparatus according to a sixth embodiment of the present invention will be explained with reference to FIG. 10. The same members of the present embodiment as those of the chemical substance detecting method and apparatus according to the fifth embodiment shown in FIG. 9 are represented by the same reference numbers not to repeat or to simplify their explanation. FIG. 10 is a diagrammatic view of the chemical substance detecting method and apparatus according to the present embodiment.

As shown in FIG. 10, the chemical substance detecting apparatus according to the present embodiment is characterized in that the filter 50 is not provided between the chemical substance decomposing chamber 12 and the chemical substance detecting chamber 14 of the chemical substance detecting apparatus according to the fifth embodiment shown in FIG. 9.

The filter 50 is provided for prohibiting smoke particles having large molecular weights from entering the detection chamber 14 so as to prevent infrared radiation, the measurement radiation, from being absorbed by the smoke

particles to resultantly lower detection sensitivity. However, the filter 50 is not essential in a case where smoke particles little absorb infrared radiation, and infrared absorption spectrum of chlorine eliminated from dioxin can be sufficiently obtained. This constitution of the chemical substance detecting apparatus makes the structure simple.

As described above, according to the present embodiment, it is not necessary to divide the decomposition chamber 12 from the detection chamber 14 by the filter 50, which makes the structure of the apparatus simple.

[INDUSTRIAL APPLICABILITY]

In the chemical substance detecting method and apparatus according to the present invention, a substance-to-be-measured is decomposed, a chemical substance characterizing the substance-to-be-measured generated by the decomposition is selectively introduced into the detection system and detected, whereby a substance-to-be-detected can be indirectly detected. The chemical substance detecting method and apparatus according to the present invention are useful to measure real time with high sensitivity various chemical substances including chemical substances, such as dioxin, etc., which are generated, adhering to impurity particles.

CLAIMS

1. A chemical substance detecting apparatus comprising:

a chemical substance decomposing means for decomposing a substance-to-be-detected adhering to an impurity and eliminating from the impurity a chemical substance characterizing the substance-to-be-detected;

a chemical substance detecting means for detecting the chemical substance; and

a filter for selectively admitting the chemical substance to the chemical substance detecting means,

the substance-to-be-detected being indirectly detected based on a detected result of the chemical substance.

2. A chemical substance detecting apparatus comprising:

a chemical substance decomposing means for decomposing a substance-to-be-detected adhering to an impurity and eliminating from the impurity a chemical substance characterizing the substance-to-be-detected; and

a chemical substance detecting means for detecting the chemical substance,

the substance-to-be-detected being indirectly detected based on a detected result of the chemical substance.

3. A chemical substance detecting apparatus according to claim 1 or 2, wherein

the chemical substance decomposing means is an UV radiation generator for applying an UV radiation to the substance-to-be-detected.

4. A chemical substance detecting apparatus according to claim 1 or 2, wherein

the chemical substance decomposing means is a plasma generator for exposing the substance-to-be-detected to a plasma.

5. A chemical substance detecting apparatus according to claim 4, wherein

the plasma generator produces the plasma by a high-voltage pulse.

6. A chemical substance detecting apparatus according to claim 4, wherein

the plasma generator produces the plasma by a microwave.

7. A chemical substance detecting apparatus according to any one of claims 1 to 6, wherein

the chemical substance detecting means comprises: an infrared radiation source for applying an infrared radiation to an atmosphere containing the chemical substance; and an infrared radiation detector for detecting the infrared radiation emitted from the atmosphere, the chemical substance being detected based on an absorbed quantity of the detected infrared radiation.

8. A chemical substance detecting apparatus

according to any one of claims 1 to 6, wherein

the chemical substance detecting means comprises: an infrared transmitting substrate for adhering the chemical substance; an infrared radiation source for applying an infrared radiation to the infrared transmitting substrate; and an infrared radiation detector for detecting the infrared radiation which has undergone multiple reflection inside the infrared transmitting substrate and exited the infrared transmitting substrate, the chemical substance being detected based on an absorbed quantity of the detected infrared radiation.

9. A chemical substance detecting apparatus according to claim 8, further comprising

an UV radiation applying means for applying an UV radiation to the infrared transmitting substrate to clean surfaces of the infrared transmitting substrate.

10. A chemical substance detecting apparatus according to any one of claims 7 to 9, wherein

the chemical substance detecting means further comprises a spectroscope which spectrally analyzes the infrared radiation detected by the infrared radiation detector, and identifies a kind of the chemical substance and/or quantifies the chemical substance.

11. A chemical substance detecting method comprising:

decomposing a substance-to-be-detected adhering to an impurity;

eliminating from the impurity a chemical substance characterizing the substance-to-be-detected;

detecting the eliminated chemical substance; and

indirectly detecting the substance-to-be-detected, based on a detected result of the chemical substance.

12. A chemical substance detecting method according to claim 11, wherein

the eliminated chemical substance is detected after separated from the impurity.

FIG.1

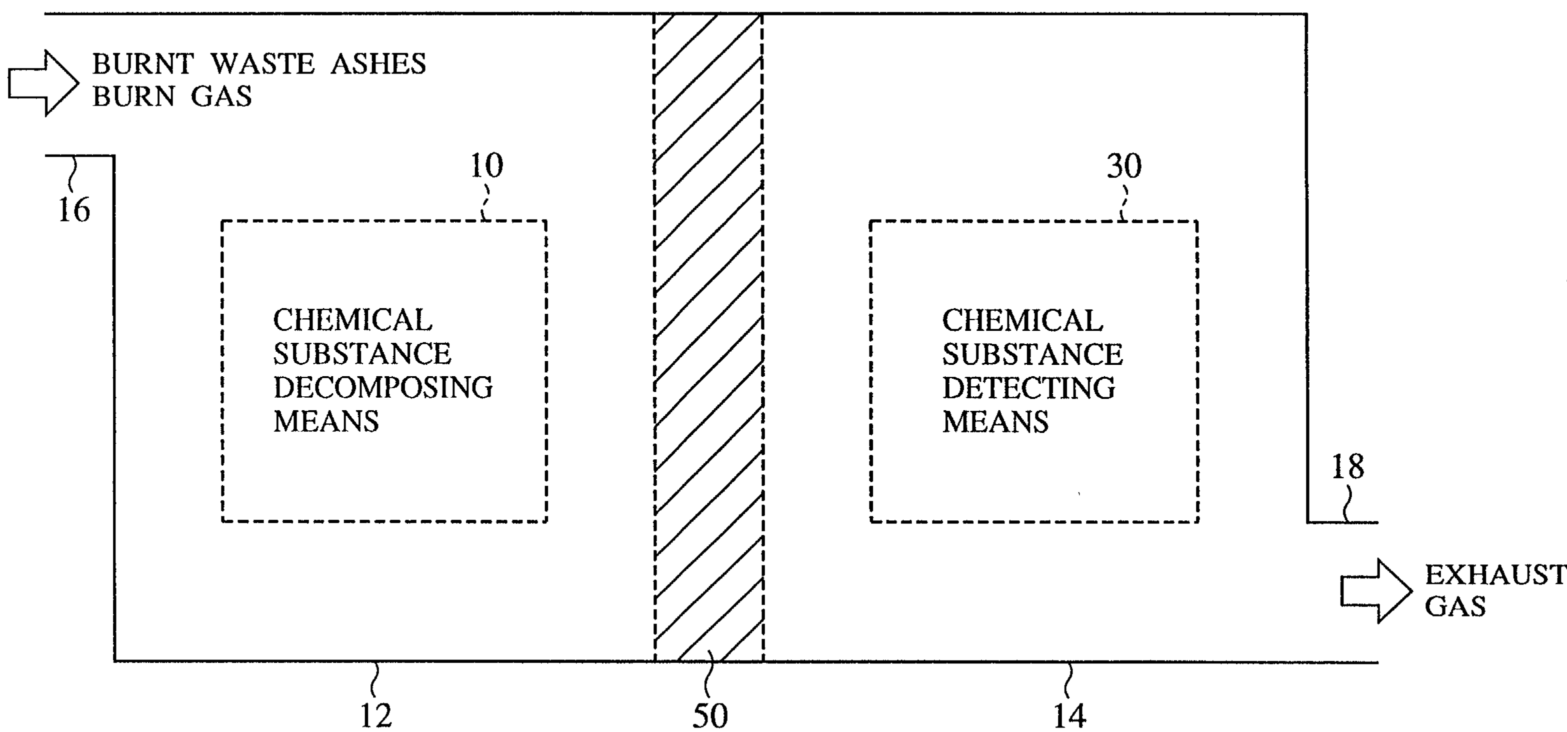

BURNT WASTE ASHES
BURN GAS
16
10
CHEMICAL SUBSTANCE DECOMPOSING MEANS
30
CHEMICAL SUBSTANCE DETECTING MEANS
18
EXHAUST GAS
12
50
14

FIG.2

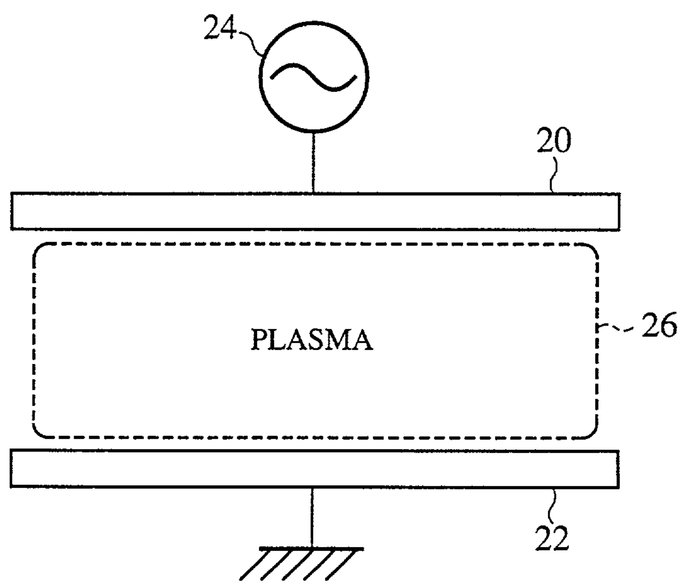


FIG.3

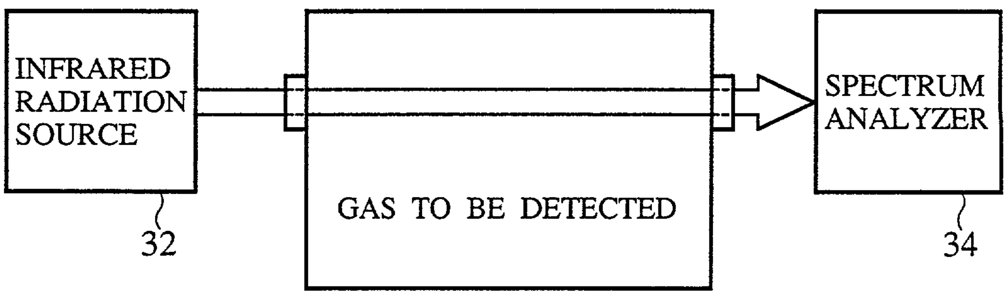

INFRARED
RADIATION
SOURCE
GAS TO BE DETECTED
SPECTRUM
ANALYZER
32
34

FIG.4

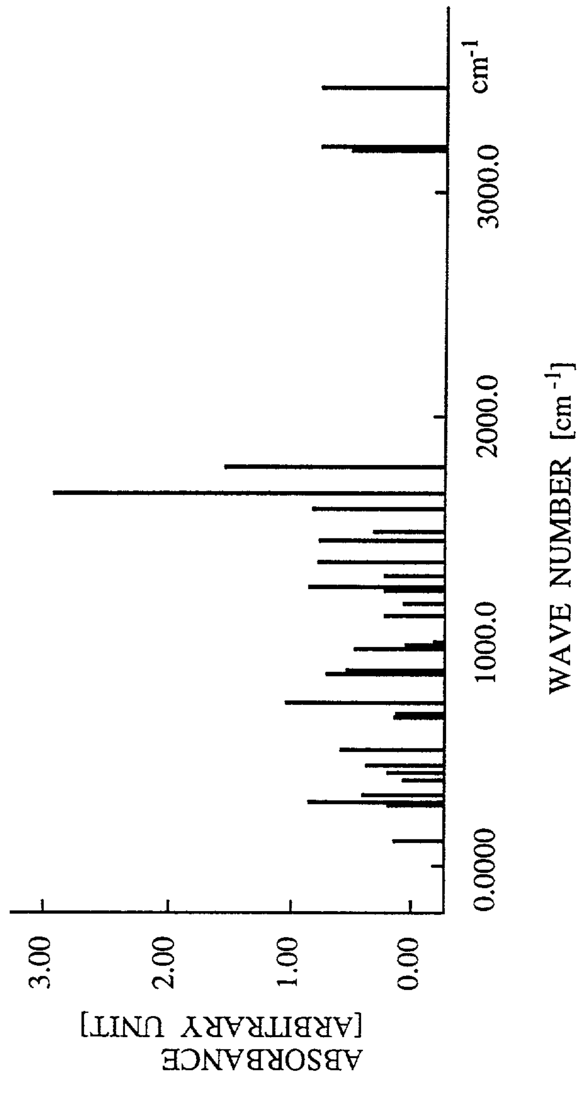

ABSORBANCE
[ARBITRARY UNIT]
3.00
2.00
1.00
0.00
0.0000
1000.0
2000.0
3000.0
cm-1
WAVE NUMBER [cm-1]

FIG.5

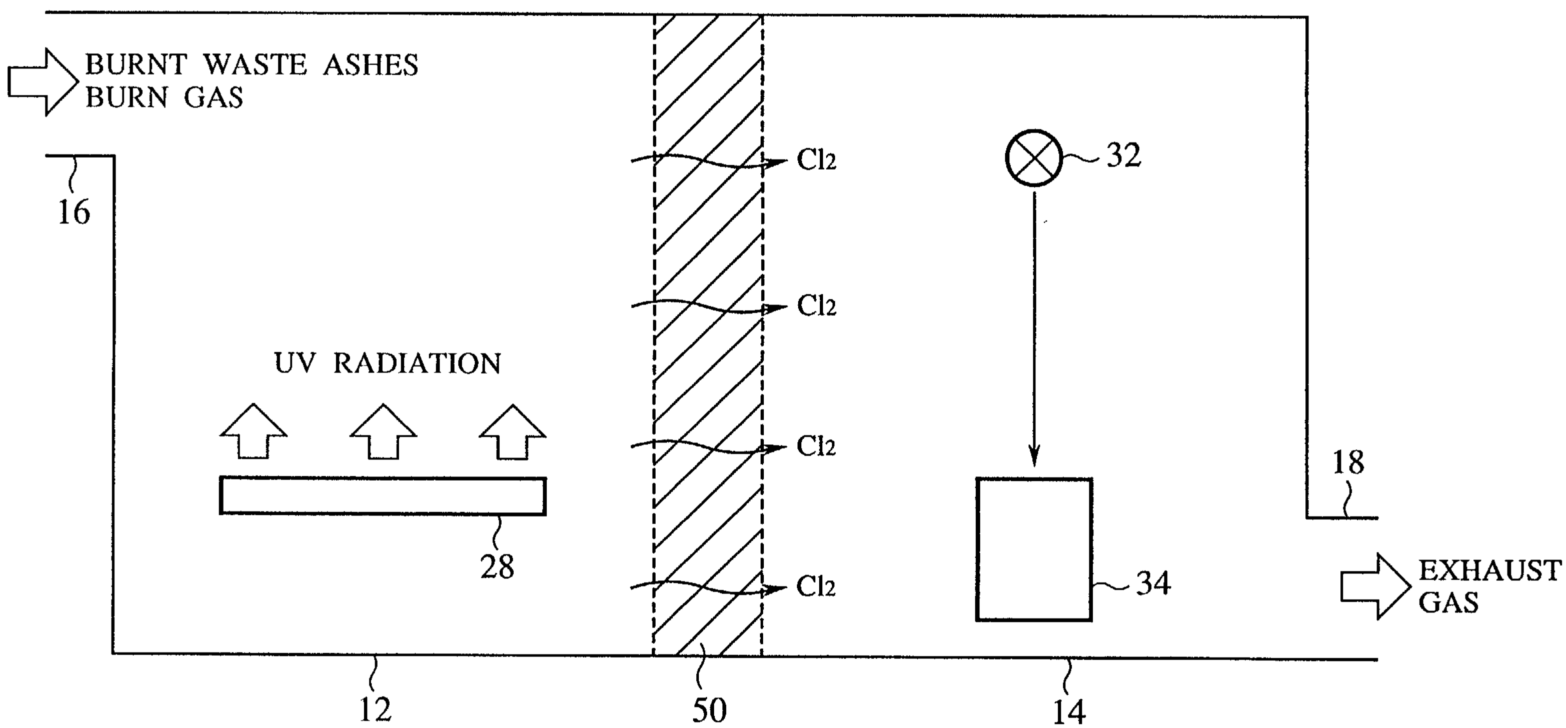

BURNT WASTE ASHES
BURN GAS
16
UV RADIATION
28
12
Cl2
Cl2
Cl2
Cl2
50
32
34
14
18
EXHAUST
GAS

FIG.6

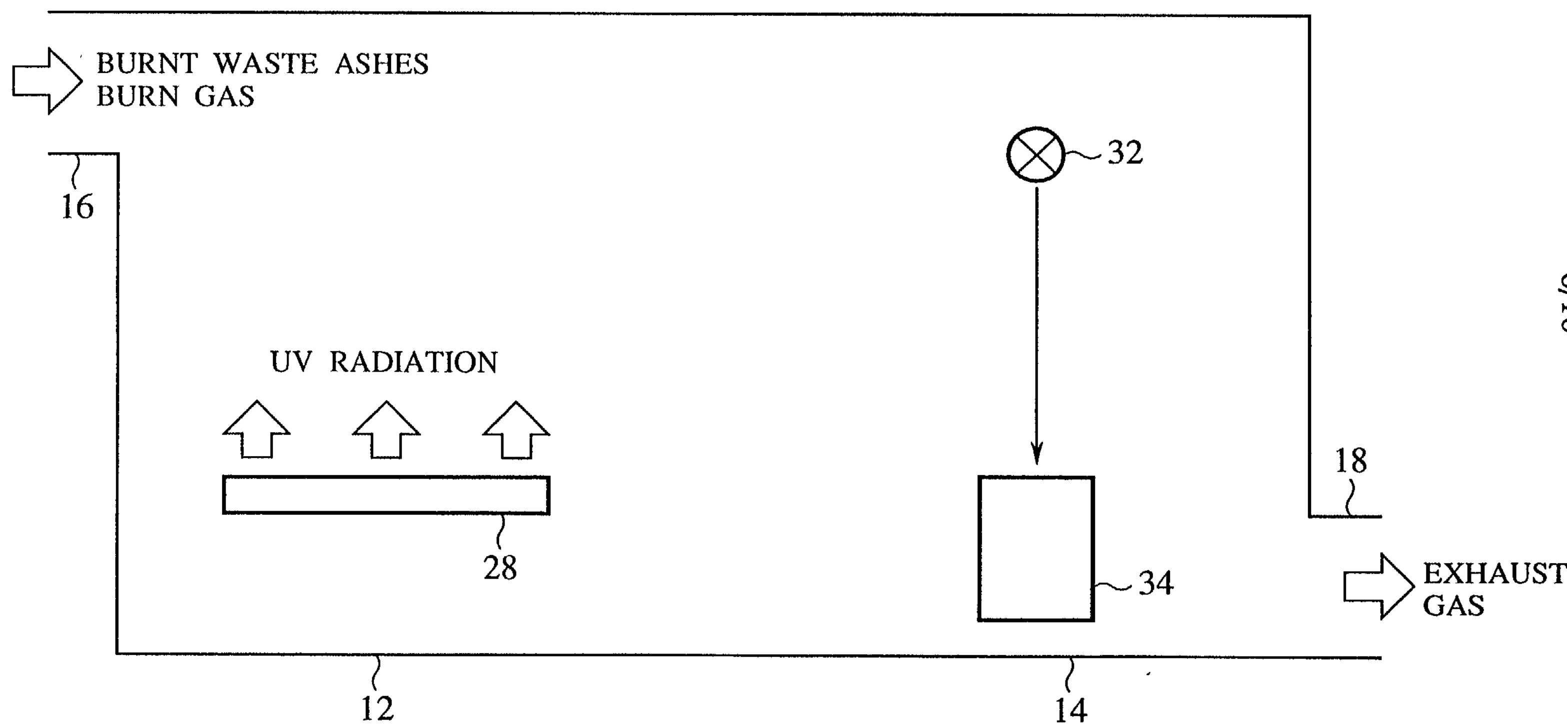

BURNT WASTE ASHES
BURN GAS
16
UV RADIATION
28
12
32
34
14
18
EXHAUST
GAS

FIG.7

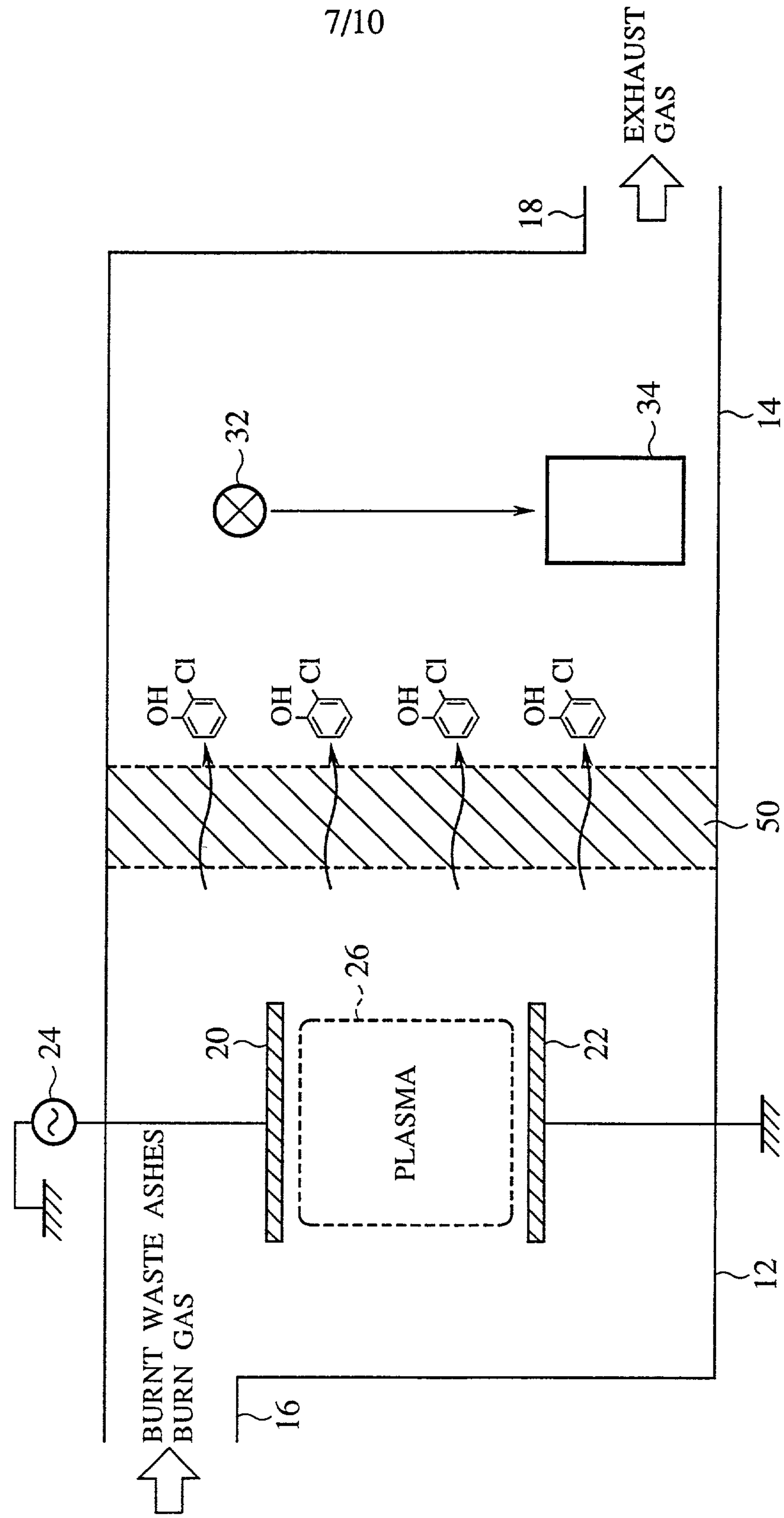

EXHAUST GAS
18
32
34
14
OH
Cl
50
26
24
20
22
PLASMA
BURNT WASTE ASHES
BURN GAS
12
16

FIG.8

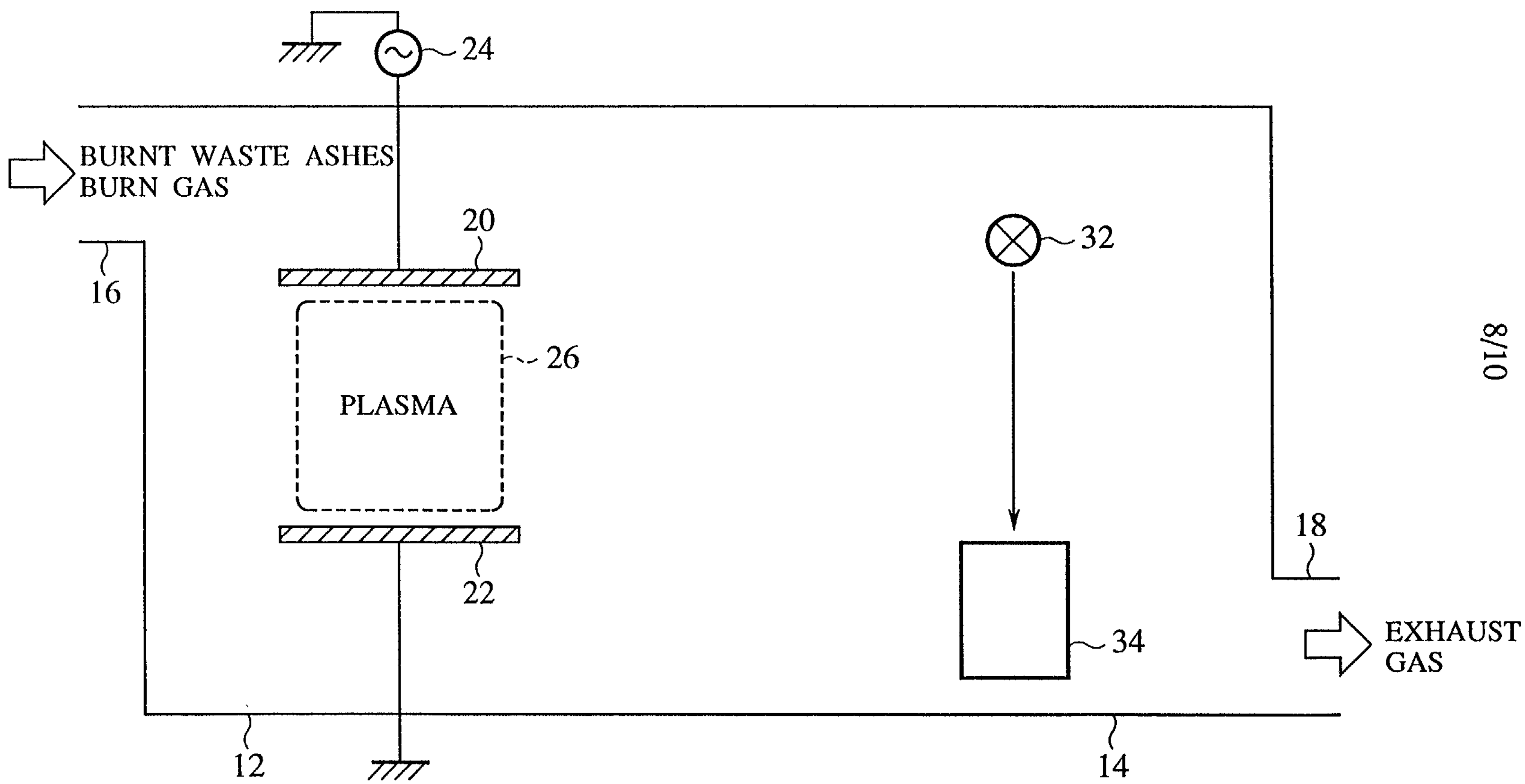

24
BURNT WASTE ASHES
BURN GAS
20
16
26
PLASMA
22
12
32
34
18
EXHAUST
GAS
14

FIG.9

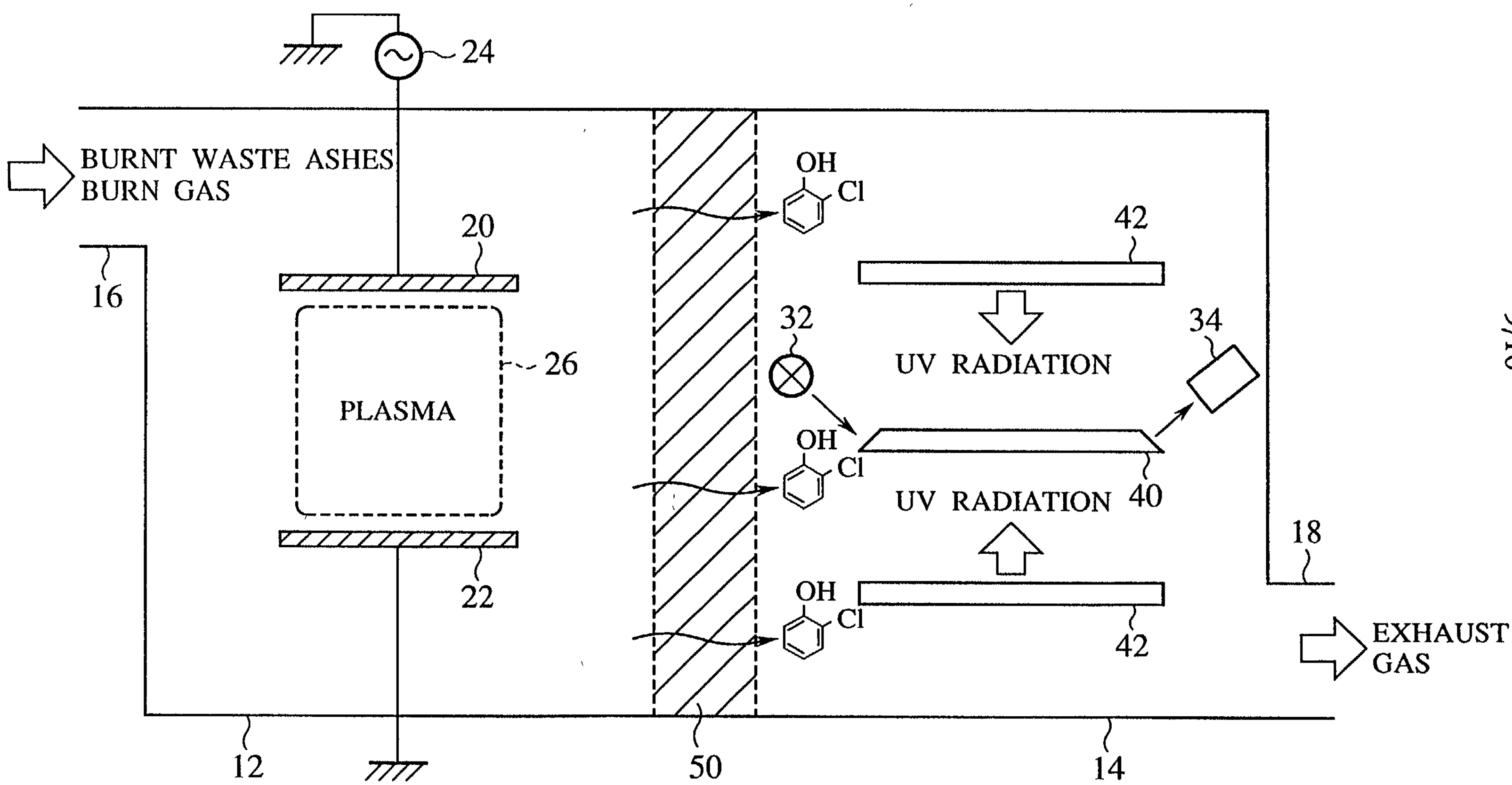
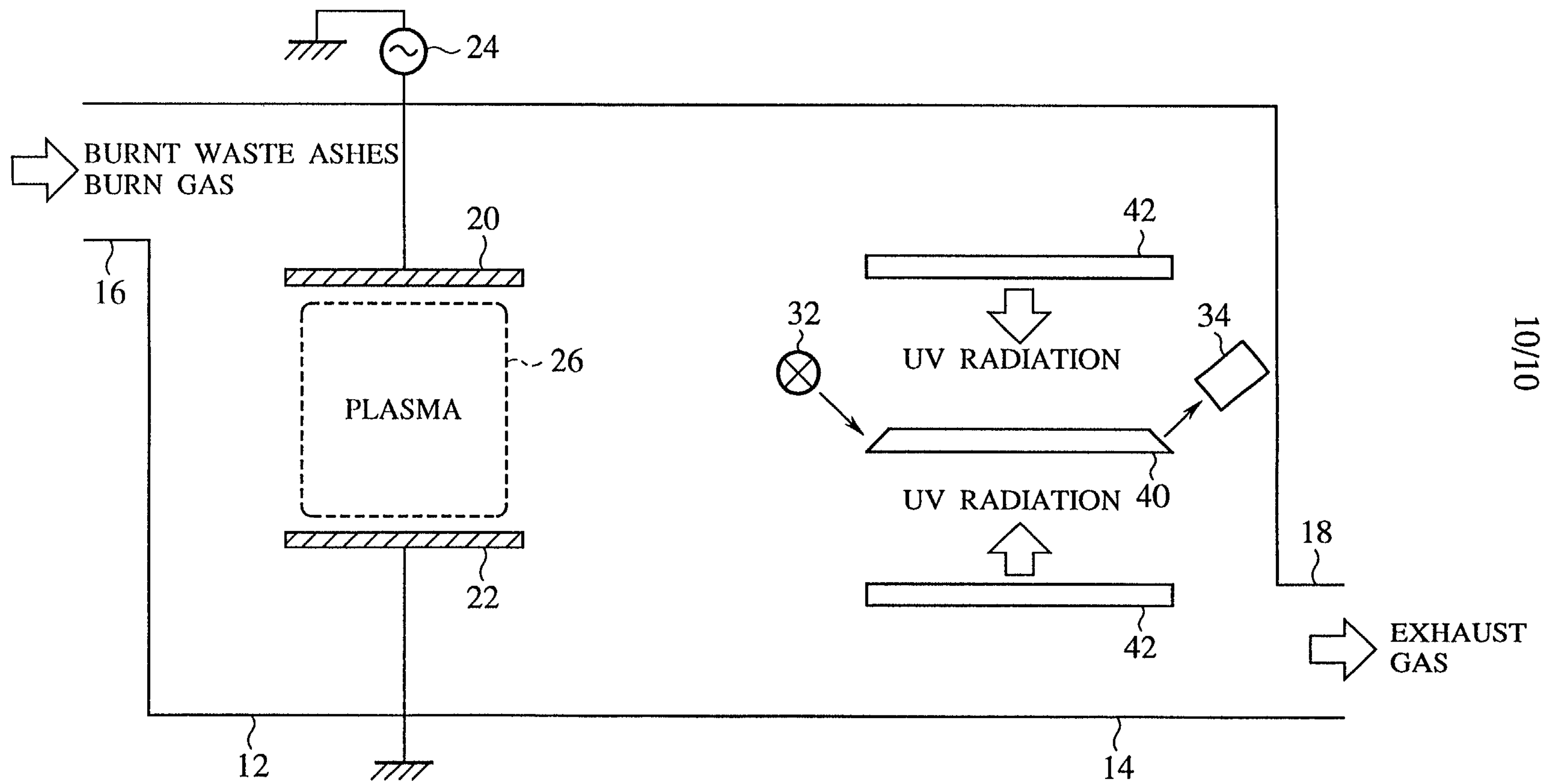

24
BURNT WASTE ASHES
BURN GAS
20
16
26
PLASMA
22
12
50
OH
Cl
32
42
UV RADIATION
34
40
18
EXHAUST
GAS
14

FIG.10


24
BURNT WASTE ASHES
BURN GAS
20
16
26
PLASMA
22
12
42
32
UV RADIATION
34
40
UV RADIATION
18
42
EXHAUST
GAS
14

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#3

DECLARATION AND POWER OF ATTORNEY - USA PATENT APPLICATION

As a below named inventor, I hereby declare that:

My residence, post office address and citizenship are as stated below next to my name;

I believe I am an original, first and sole inventor of the subject matter which is claimed and for which a patent is sought on the invention entitled **CHEMICAL SUBSTANCE DETECTING METHOD AND APPARATUS**; the International application for a letter of patent was filed on October 26, 2000 with International Application No. **PCT/JP00/07499** and an application for entering the national stage of United States of America under 35 U.S.C. 371 (c) was filed on August 31, 2001 with the assigned application No. **09/914,818**;

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims, as amended by any amendment referred to above;

I acknowledge the duty to disclose information which is material to patentability as defined in Title 37, Code of Federal Regulations, § 1.56;

I hereby claim foreign priority benefits under Title 35, United States Code, § 119(a)-(d) of any foreign application(s) for patent or inventor's certificate listed below and have also identified below any foreign application for patent or inventor's certificate having a filing date before that of the application on which priority is claimed:

PRIOR FOREIGN APPLICATION(S) — Priority Claimed

No.: **2000-963** Country: **Japan** Date Filed: **January 6, 2000** — **Yes**

POWER OF ATTORNEY: I hereby appoint the following agents and/or attorneys to prosecute this application and to transact all business in the Patent and Trademark Office connected therewith (if this application is assigned, I acknowledge that the appointed individuals do not represent me, and that instead they represent the assignee): Yasuo Muramatsu, Registration No. 38,684, and Hideki Muramatsu, Registration No. 45,577.

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful, false statements may jeopardize the validity of the application or any patent issued thereon.

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Inventor's signature

Date 12-Nov. 2001

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